

CLAIMS

What is claimed is:

- 1 1. In a charge pump having first and second flying
2 capacitors and providing a regulated charge pump output, a
3 method of pumping charge comprising:
4 providing a first signal responsive to the difference
5 between a feedback signal from the charge pump output and a
6 reference; and,
7 alternately switching between:
8 a) coupling the first flying capacitor between
9 first and second power supply terminals, and coupling
10 the second flying capacitor between the first signal and
11 the charge pump output; and,
12 b) coupling the second flying capacitor between
13 first and second power supply terminals, and coupling
14 the first flying capacitor between the first signal and
15 the charge pump output;
16 the charge pump output, the first signal and the voltage
17 on the flying capacitor coupled between the first signal and
18 the charge pump output forming a continuous linear regulation
19 loop.

1 2. The method of claim 1 wherein the first signal is
2 provided by an amplifier, and the switching is done before
3 the amplifier saturates.

1 3. The method of claim 2 wherein the switching occurs
2 when the output of the amplifier reaches a voltage a
3 predetermined increment away from saturation.

1 4. The method of claim 2 wherein the switching is done
2 when the output of the amplifier reaches a predetermined
3 voltage.

1 5. The method of claim 4 wherein the output of the
2 amplifier is compared with a second reference, and wherein
3 the switching is controlled by the complimentary change of
4 state of a circuit triggered by a pulse resulting from a
5 predetermined change of state of the comparison.

1 6. The method of claim 4 further comprising starting
2 the charge pump by forcing the switching to occur.

1 7. The method of claim 4 further comprising starting
2 the charge pump by forcing the switching to occur at the
3 maximum rate the charge pump will operate.

1 8. The method of claim 4 further comprising starting
2 the charge pump by forcing the switching to occur at any rate
3 up to the maximum rate the switching may be accomplished.

1 9. The method of claim 2 wherein the amplifier is a
2 differential amplifier and one input to the differential
3 amplifier is coupled to a reference voltage.

1 10. The method of claim 1 wherein the reference voltage
2 is a power supply voltage.

1 11. The method of claim 1 wherein the reference voltage
2 is proportional to a power supply voltage.

1 12. The method of claim 1 wherein the switching occurs
2 at a fixed frequency.

1 13. The method of claim 1 wherein the feedback signal
2 is obtained from a voltage divider coupled between the charge
3 pump output and the first power supply terminal.

1 14. The method of claim 1 wherein the feedback signal
2 is obtained by level shifting the charge pump output.

1 15. A charge pump comprising: ~
2 first and second flying capacitors;
3 an amplifier;

4 a plurality of switches;
5 the amplifier being coupled to provide an output
6 responsive to the difference between a voltage responsive to
7 an output voltage of the charge pump and a reference;
8 the switches being coupled to alternately switch
9 between:

10 a) coupling the first flying capacitor between
11 first and second power supply terminals, and coupling
12 the second flying capacitor between the amplifier output
13 and the charge pump output; and,

14 b) coupling the second flying capacitor between
15 first and second power supply terminals, and coupling
16 the first flying capacitor between the amplifier output
17 and the charge pump output.

1 16. The charge pump of claim 15 further comprised of
2 switch control circuitry causing the alternating switching
3 before the amplifier reaches saturation.

1 17. The charge pump of claim 16 wherein the switch
2 control circuitry comprises a comparator coupled to compare
3 the output of the amplifier to a second reference, an output
4 of the comparator pulsing a divide by two circuit, the output
5 of the divide by two circuit controlling the plurality of
6 switches.

1 18. The charge pump circuit of claim 17 wherein the
2 divide by two circuit is a D flip-flop.

1 19. The charge pump of claim 15 wherein the switches
2 are MOS transistor switches.

1 20. The charge pump of claim 15 wherein the amplifier
2 is a differential amplifier.

1 21. The charge pump of claim 20 further comprising a
2 voltage divider coupled to feed back the output voltage of
3 the charge pump to the differential amplifier.

1 22. The charge pump of claim 15 wherein the reference
2 is a power supply voltage.

1 23. The charge pump of claim 15 wherein the reference
2 is proportional to a power supply voltage.

1 24. The charge pump of claim 15 wherein the output of
2 the charge pump is a level shifted charge pump output.

1 25. A charge pump comprising:
2 first and second flying capacitors;
3 an amplifier;
4 a plurality of switches;

5 the amplifier being coupled to provide an output
6 responsive to an output voltage of the charge pump;
7 the switches being coupled to alternately switch
8 between:

9 a) coupling the first flying capacitor between
10 first and second power supply terminals, and coupling
11 the second flying capacitor between the amplifier output
12 and the charge pump output; and,

13 b) coupling the second flying capacitor between
14 first and second power supply terminals, and coupling
15 the first flying capacitor between the amplifier output
16 and the charge pump output.

1 26. The charge pump of claim 25 further comprised of
2 switch control circuitry causing the alternating switching
3 before the amplifier reaches saturation.

1 27. The charge pump of claim 26 wherein the switch
2 control circuitry comprises a comparator coupled to compare
3 the output of the amplifier to a reference, an output of the
4 comparator pulsing a divide by two circuit, the output of the
5 divide by two circuit controlling the plurality of switches.

1 28. The charge pump circuit of claim 27 wherein the
2 divide by two circuit is a D flip-flop.

1 29. The charge pump of claim 25 wherein the switches
2 are MOS transistor switches.

1 30. The charge pump of claim 25 wherein the amplifier
2 is a differential amplifier having an input coupled to a
3 reference.

1 31. The charge pump of claim 30 further comprising a
2 voltage divider coupled to feed back the output voltage of
3 the charge pump to the differential amplifier.

1 32. The charge pump of claim 30 wherein the reference
2 is a power supply voltage.

1 33. The charge pump of claim 30 wherein the reference
2 is proportional to a power supply voltage.

1 34. The charge pump of claim 25 wherein the output of
2 the charge pump is a level shifted charge pump output.